Radiation Reaction Enhancement Due to Decay of Emitted Photons

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In a high magnetic field vacuum becomes polarized, and its refractive index can noticeably differ from unity. For instance, in the constant magnetic field $B = 10^{-3} B_{cr}$ the real part of the emergent refractive index is about $\mathrm{Re}(n-1) \sim 10^{-10}$ for photons with $\varkappa \lesssim 1$. Here $\varkappa = (B/B_{cr})(\hbar\omega/mc^2)$, ω the photon frequency, $B_{cr} = m^2c^3/e\hbar$ the Sauter–Schwinger field (the critical field of the quantum electrodynamics), m and e the electron mass and charge value, c the speed of light and $\hbar$ the reduced Plank's constant. This tiny change in n is enough to yield 10% change inthe emission spectrum of muons with Lorentz-factor $\gamma = 2 \times 10^4$. In this case the emission occurs in the synergic synhrotron-Cherenkov regime [1]. However, Ref. [1] doesn't take into account the imaginary part of the refractive index.

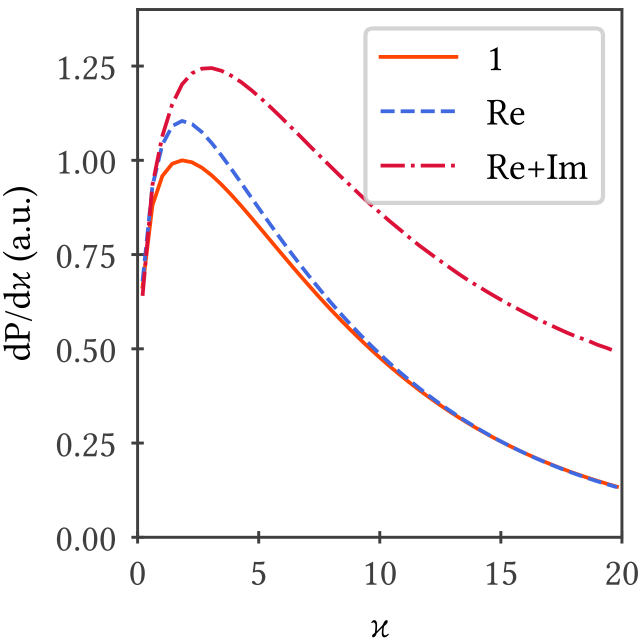

Figure 1: The spectrum of the radiation losses by a muon with $\gamma B/B_{cr} = 30$. Line "1" is the classical synchrotron spectrum, lines "Re" and "Re+Im" are computed with only real and both real and imaginary parts of the vacuum refractive index taken into account

The imaginary part of the refractive index of the polarized vacuum corresponds to the photon decay due to the pair photoproduction. Obviously, if the decay length is less or about the synchrotron-Cherenkov radiation formation length, the photon decay can affect the emission process, i.e. the pair photoproduction can affect the radiation reaction. For the above-mentioned parameters photon emission by muons can be considered in the framework of the classical electrodynamics [1]. Note, however, that the "emission spectrum" is meaningless if the photons decay, but the spectrum of the radiation losses can be obtained which can be used to find the final muon spectrum.

In this presentation the analytical expression for the spectrum of the radiation losses is obtained with both real and imaginary parts of the vacuum refractive index taken into account. For the high-frequency tail of the spectrum, the computed spectrum goes higher than the classical synchrotron spectrum if the photon decay length is about or shorter than the radiation formation length (see Fig. 1). Mathematically, the losses are determined by a convolution of a smooth function with an oscillating function, thus the shorter integration length leads to the higher integral value hence higher losses. It is also shown that the effect of the photon decay is more valuable than the effect of the real part of the vacuum polarization.

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References

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